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RESEARCH ARTICLE

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Ambulance diversions following public hospital emergency department closures

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Objective: To examine whether hospitals are more likely to temporarily close their emergency departments (EDs) to ambulances (through ambulance diversions) if neighboring diverting hospitals are public vs private.

Data Sources/Study Setting: Ambulance diversion logs for California hospitals, discharge data, and hospital characteristics data from California's Office of Statewide Health Planning and Development and the American Hospital Association (2007).

Study Design: We match public and private (nonprofit or for-profit) hospitals by distance and size. We use random-effects models examining diversion probability and timing of private hospitals following diversions by neighboring public vs matched private hospitals.

Data Collection/Extraction Methods: N/A.

Principal Findings: Hospitals are 3.6 percent more likely to declare diversions if neighboring diverting hospitals are public vs private ($P < 0.001$). Hospitals declaring diversions have lower ED occupancy ($P < 0.001$) after neighboring public (vs private) hospitals divert. Hospitals have 4.2 percent shorter diversions if neighboring diverting hospitals are public vs private ($P < 0.001$). When the neighboring hospital ends its diversion first, hospitals terminate diversions 4.2 percent sooner if the neighboring hospital is public vs private ($P = 0.022$).

Conclusions: Sample hospitals respond differently to diversions by neighboring public (vs private) hospitals, suggesting that these hospitals might be strategically declaring ambulance diversions to avoid treating low-paying patients served by public hospitals.

KEYWORDS
access to care, ambulance diversion, emergency department

1 | INTRODUCTION

In 2003, approximately one-third of U.S. hospitals temporarily closed their emergency departments (EDs) to ambulances by declaring an ambulance diversion.[1] Ambulance diversions delay emergency care,[2,3] and have been associated with increased mortality,[4,5] particularly for patients with time-sensitive conditions such as acute myocardial infarctions.[6-8] Although many hospitals divert because their EDs are crowded,[3,9,10] diversions may occur for other reasons.[11] Previous research suggests that hospitals may defensively divert when neighboring hospitals declare diversions[10] to prevent being overwhelmed by the neighboring hospital's patients.[12,13] This paper

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examines another cause for diversions: whether hospitals divert to avoid patients from public hospitals.

Although previous research modeled the economic benefits to hospitals of diverting uninsured and Medicaid patients,[12] no study has examined whether hospitals actually do so. Here, we apply four tests for whether hospitals change their diversion behavior when a neighboring hospital on diversion is a public hospital, a behavior we term "strategic diversions." First, we ask whether, after a neighboring hospital declares a diversion, hospitals are more likely to declare their own diversions if the neighboring hospital is public vs private. Second, we test whether hospitals divert at a lower ED census when neighboring public (vs private) hospitals go on diversion. The third and fourth tests focus on the potential costs of diversion—lower revenue and gross margins[14,15]—and suggest that a hospital diverting for strategic reasons may want to end its diversion sooner than a hospital diverting for capacity reasons. In the third test, we examine whether diversions are shorter when hospitals divert subsequent to a neighboring public, vs private, hospital's diversion. Finally, we examine hospitals' responsiveness to a neighboring hospital ending its diversion, examining whether responding hospitals end their diversions sooner after a neighboring hospital ends its diversion if the neighboring hospital is a public, vs private, hospital.

2 | BACKGROUND

It is unknown whether hospitals are more likely to defensively divert after diversions by public hospitals compared to private (nonprofit or for-profit) hospitals. A hospital wishing to avoid low-paying patients has reason to avoid patients who are treated at public hospitals, including their EDs. Public hospitals are more likely to serve Medicaid or uninsured patients, who are less profitable than others. Estimated ED profit margins are −54.4 percent for uninsured and −35.9 percent for Medicaid patients, compared with −15.6 percent for Medicare and 39.6 percent for privately insured patients.[16] Adjusted mean ED payments are lower for uninsured and Medicaid patients (30 and 50 percent, respectively) than for commercially insured patients.[17] Furthermore, uninsured and Medicaid patients are often more medically complex and consequently require more resources than privately insured patients.[18] Providers may also believe, perhaps inaccurately,[19] that these patients increase their malpractice risk.[20,21]

Moreover, laws intended to protect patients from being turned away because of insurance status may not apply in the diversion setting, leaving uninsured and Medicaid-insured patients at risk. For example, Medicare-participating hospitals are prohibited by the Emergency Medical Treatment and Labor Act (EMTALA) from denying patients' emergency care based on their insurance status.[22] However, hospitals wishing to avoid Medicaid and uninsured patients might strategically declare an ambulance diversion when neighboring public, vs private, hospitals are on diversion. Not only would this likely not draw as much scrutiny as directly denying these unprofitable patients' emergency care, but under current regulations, hospitals might still be in compliance with EMTALA even if they strategically declare diversions, since the patients never arrive at the first hospital (Appendix S1). Nonetheless, such strategic diversions would unnecessarily reduce or delay access to emergency services to ED patients treated by public hospitals and undermine EMTALA's purpose.

3 | METHODS

3.1 | Study design and data sources

We apply a retrospective analysis using 2007 California data. The units of analysis are hospital ED diversions leading to temporary emergency department closings in hospitals with neighboring public or private hospitals that had previously initiated an ambulance diversion. We examine only complete hospital diversions. The observation hospitals whose diversions are analyzed are private hospitals, both nonprofit and for-profit hospitals, with a public hospital of similar size located within 25 miles of the observation hospital and which are located in regions in which time-stamped diversion data are available.

We create our sample from hospitals listed in 2007 ambulance diversion logs that report start and end time for each hospital's diversion. We use 2007 data because it is the last year that Los Angeles County (which accounts for 22 percent of all California hospitals) provided detailed data, so using more recent data would exclude a significant portion of the state and raise concerns about external validity. However, we examine more recent aggregated data on diversion hours and find that neither the percent of hospitals within our sample that declared an ambulance diversion nor the amount of time that these hospitals were on diversion changed significantly from 2007 to the most recent year that these data were reported (for most hospitals, 2015; 82 percent vs 71 percent, $P = 0.342$ and 869 hours and 676 hours, $P = 0.4454$, respectively).*

From the diversion logs, we identify 178 nonfederal, general hospitals and match diversion log data with ED and inpatient discharge data from the State of California Office of Statewide Health Planning and Development (OSHPD) and data on hospital and financial characteristics from OSHPD and the American Hospital Association's Annual Survey.

There are 33 local EMS agencies (LEMSAs) in California, of which 29 permitted ambulance diversions in 2007.[23] Researchers previously collected ambulance diversion logs from 15 of these LEMSAs (covering 61 percent of general medical hospitals in the state with EDs). We exclude data from five LEMSAs without identifiable hospital names or for which only aggregated data are available.

We exclude twenty hospitals (11.2 percent) consisting of (a) six hospitals in LEMSAs that had fewer than three hospitals with diversions, because such a small number would not allow us to measure responsive diversion behavior; (b) two hospitals in diversion logs that could not be matched to OSHPD data; (c) five hospitals that participated in a project to reduce diversion hours,[24] which may confound results; (d) six public hospitals that had fewer than 15 diversions in

2007; and (e) one public hospital that did not have any neighboring private hospitals.

Among the remaining 158 hospitals, we classify hospitals into public and private hospitals. There are sixteen public hospitals and 142 private hospitals.

We restrict the sample to 28 private hospitals that had public hospitals of similar size (as measured by annual ED visits and bed size) within 25 miles. Driving distance is generated using Google Maps API. The sample is restricted to hospitals of similar size so that emergency medical services would see the neighbor hospital as a reasonable alternative to the hospital initially on diversion. We do not restrict the number of private hospitals a priori, but find in matching that markets do not include more than three private hospitals of similar size and distance.

3.2 | Outcome and explanatory variables

We use three outcome variables to identify responsiveness to diversions of neighboring hospitals. First, a dichotomous variable measures whether a hospital declares a diversion after a neighboring hospital declares a diversion, but while the neighboring hospital is still on diversion status.

Second, we use the number of minutes of the observation hospital's diversion. A hospital diverting for strategic reasons may want to end their diversions sooner than a hospital diverting for capacity reasons. This is because diversions have been associated with lower revenue and gross margins,[14,15] so hospitals that are strategically diverting may want to balance avoiding unprofitable patients being diverted from public hospitals with losing profitable patients that are in their usual catchment areas. The length of the diversion has a long tail, so we exclude observations where the outcome is above the 95th percentile (>171 minutes), although we include these in sensitivity analyses.

Third, we use the number of minutes from the time the neighboring hospital terminates its diversion until the observation hospital ends its own diversion. This outcome proxies how responsive the observation hospital is to when the neighboring hospital ends its diversion. Cases in which the observation hospital terminates its diversion before the neighboring hospital are excluded from the analysis, but we include these in sensitivity analyses. The time elapsed between the two hospitals ending their respective diversions has a long tail, so as with the second outcome, we exclude observations where the outcome is above the 95th percentile (>119 minutes), although we also include these in sensitivity analyses.

3.3 | Statistical methods

We estimate the following equation as an instrumental variable linear probability model, with hospital-level random effects:

$$\begin{aligned} Y = fn(&\text{neighbor ownership} + \text{neighbor ownership} \times \text{ED occupancy} \\ &+ \text{neighbor ownership} \times \text{ED crowding} + \text{ED occupancy} \\ &+ \text{ED crowding} + \text{diversion} + \text{hosp-pair} + \text{hosp}), \end{aligned} \tag{1}$$

where Y represents the outcomes described above (ie whether the observation hospital declares a diversion while the neighboring diverting hospital is still on diversion status (a linear probability model); the duration of the diversion; and the time elapsed between the neighboring hospital and observation hospital end their respective diversions); neighbor ownership is whether the neighboring hospital is public or private; ED occupancy is the predicted number of ED patients in the observation hospital; ED crowding are variables that indirectly measure ED crowding; diversion are diversion-specific characteristics; hosp-pair are characteristics specific to the observation hospital and neighboring hospital; and hosp represents hospital-specific characteristics. All predictor variables are described below. Because the interaction terms were not statistically significant for the duration and timing outcomes, we report the main effects for those outcomes (ie Equation (1) minus the interactions) and the fixed parameters of the model.

3.3.1 | Main predictor variables

The two main predictor variables are neighbor ownership and the interaction of neighbor ownership × ED crowding. Neighbor ownership tests whether the responsiveness of observation hospitals to neighboring hospital diversions depends on whether the neighboring hospital is public or private. As discussed above, if hospitals strategically divert, we expect the likelihood of declaring the diversion to be higher and the time to the end of the diversion to be shorter if the neighboring diverting hospital is public.

The second main predictor variable is the interaction of whether the neighboring hospital is public or private with ED occupancy at the observation hospital. ED occupancy is included as a covariate because the likelihood of diversion should be higher when ED census at the observation hospital is higher. Because this is derived from discharge data, patients who are boarding (ie admitted but waiting for a bed) are not included in this measure of ED occupancy. To test whether hospitals initiate diversions at lower ED occupancy when a neighboring public hospital declares a diversion, we interact the ED census with the indicator of whether the neighboring diverting hospital is a public hospital. As discussed above, if hospitals strategically divert, we expect that the interaction of whether the neighboring hospital is a public (vs private) hospital with the observation hospital's ED occupancy to be negative.

Emergency department occupancy is measured on a daily basis. A hospital that has been on diversion may have lower occupancy than if it had not diverted, raising issues of reverse causality. To address this, we use instrumental variable regression to generate a predicted ED occupancy that is free of reverse causality. Our instrument is inpatient occupancy, which is related to diversions only through ED occupancy. For Equation (1), the interaction also includes an instrument for inpatient occupancy interacted with whether the neighboring hospital is a public hospital.[25]

3.3.2 | Other control variables

As described in Equation (1), we additionally control for ED crowding, diversion-specific characteristics, hospital-pair-specific characteristics, and hospital characteristics for the observation hospital.

3.3.2.1 | ED crowding

Emergency department crowding consists of three variables: the hour that the neighboring hospital declares its diversion; whether the diversion occurred on a weekend; and average physician staffing. We include hour as a measure of ED crowding to account for variation in the number of ED physicians on shift,[9] nurse staffing,[2] and demand for ambulance and ED services.[26] We additionally include whether the diversion occurred on a weekend, as hospitals are more likely to have crowding on weekends.[2,26] Physician staffing is the ratio of the average number of ED patients to the number of emergency medicine physicians with privileges (Appendix S2).

3.3.2.2 | Diversion-specific characteristics

Following previous research, we include three independent variables to control for factors associated with diversions other than census: the length of time that the neighboring hospital is on diversion;[10] the month of the diversion;[4,27] and whether ED visits are extremely high in the LEMSA for that day. We adjust for length of time that the neighboring hospital diverts in order to adjust for the influence of the neighboring hospital's diversion on the hospital of interest. We define whether ED visits are extremely high for that day as whether the daily ED occupancy rate for EDs within the entire LEMSA is above the 66th percentile. This variable, along with month, helps account for external events that may increase demand.

3.3.2.3 | Hospital-pair-specific characteristics

We also adjust for two factors specific to the hospital of interest and the original diverting hospital which proxy for the influence of the neighboring hospital's diversion on the hospital of interest: the relative driving distance between the two hospitals and the overlap in patient catchment on nondiversion days. Relative distance is the ratio of the driving distance between the hospital pair over the average driving distance of the closest five EDs. The overlap in patient catchment areas is calculated relying on Brooks and Jones[28] method for a "competitor market presence" (Appendix S2).

3.3.2.4 | Hospital-specific characteristics

We control for hospital teaching status and hospital bed size.

3.4 | Sensitivity analyses

In sensitivity analyses, we examine alternate model specifications (Appendix S3), including using actual ED census rather than instrumented census; using clustered standard errors; and including outliers. We additionally test an additional hypothesis that relied on slightly different data, whether hospitals changed the timing of the beginning of their diversions if the first hospital in a market to declare a diversion was a public vs private hospital (Appendix S4). In this hypothesis, we examine whether hospitals in a market may "race" to declare a diversion when more than two hospitals are already on diversion, and the first hospital to declare a diversion is a public, vs private, hospital. Thus, we measure whether the duration between the second and the third hospital to declare a diversion is shorter when the first hospital to declare a diversion is public vs private. Finally, we examine differences in severity of illness in diverting hospitals by whether the neighboring diverting hospital is public vs private (Appendix S5). This proxies for whether patient acuity differs on days when a neighboring hospital on diversion is public vs private.

This study was approved by the UCLA and Penn State Institutional Review Boards.

4 | RESULTS

Our study sample includes 28 private hospitals in seven California LEMSAs, which were matched to 16 public hospitals of similar size and driving distance. All but two of these private hospitals are nonprofit hospitals. The majority of public hospitals in this study are teaching hospitals (62.5 percent), with a mean bed size of 490; matched hospitals are significantly smaller (mean of 343 beds, $P = 0.0081$). Although public hospitals in our sample are larger than private hospitals, the median inpatient discharges and median ED visits per year do not differ significantly between public hospitals and matched hospitals (inpatient discharges: 22 115 vs 16 681 ($P = 0.2416$); ED visits: 50 618 vs 41 747 ($P = 0.1073$), respectively).

Although there are some differences between public and private hospitals in the matched sample, aside from patient characteristics, most differences are not statistically significant (Table 1). There is no significant difference in the number of annual diversions by public hospitals (median: 475 vs 277, $P = 0.2089$).

Public hospitals in our sample tend to treat relatively poorly insured, uninsured, and sick populations compared with their private counterparts. Public hospitals treat about 1.5 times as many ED patients ($P = 0.0178$) and 2.3 times as many inpatients ($P = 0.0001$) with Medicaid; about 24 times as many ED patients ($P < 0.0001$) and 3.7 times as many inpatients ($P < 0.001$) with no insurance; 60 percent as many ED patients ($P < 0.001$) and 65 percent as many inpatients ($P = 0.0003$) with Medicare; and 2.2 times as many ED patients ($P = 0.0034$) and 2.4 times as many inpatients ($P = 0.0055$) with dual Medicare-Medicaid eligibility. Public hospitals in our sample also are less likely to treat female patients in the ED ($P = 0.0017$) and as inpatients ($P = 0.0023$), but more likely to treat Native American/Alaska Native patients in the ED ($P = 0.0160$) and as inpatients ($P = 0.0083$).

We find evidence of sequential diversions, with unadjusted analyses finding that an average of 31.9 percent hospitals in our sample declaring a diversion after a neighboring hospital declares one (but

TABLE 1 Hospital characteristics for public hospitals and matched private hospitals

	Public hospitals	Matched private hospitals	*P*-value
Ownership			
Public	16 (100.0%)	0 (0.0%)	<0.001
Nonprofit	0 (0.0%)	26 (92.9%)	
For-profit	0 (0.0%)	2 (7.1%)	
Teaching (%)	10 (62.5%)	3 (10.7%)	<0.001
Median (IQR) ED visits per year	50 618 (28 323)	41 747 (19 446)	0.1073
Median (IQR) inpatient discharges per year	22 115 (14 398)	16 681 (10 310)	0.2416
Mean (SD) bed size	490 (187)	343 (159)	0.0081
Median (IQR) diversions	475 (1285)	277 (955)	0.2089
Characteristics of ED patients			
Mean (SD) % of ED patients who are female	49.5 (5.0)	53.8 (3.4)	0.0017
Mean (SD) % ED patients with a race of:			
White	38.9 (23.0)	53.9 (23.1)	0.0777
Black/African American	19.0 (15.6)	14.6 (13.4)	0.3980
Asian/Pacific Islander	6.6 (4.6)	6.3 (3.4)	0.8000
Native American/Alaska Native	0.9 (1.3)	0.2 (0.2)	0.0160
Other	30.4 (20.0)	19.9 (18.6)	0.1291
Missing	4.1 (10.6)	5.2 (15.4)	0.8136
Mean (SD) % of ED patients who were Hispanic	34.1 (24.9)	25.0 (17.4)	0.1614
Mean (SD) % of ED patients with:			
Medicaid	24.1 (11.0)	15.9 (10.5)	0.0178
No insurance	33.7 (20.4)	1.4 (5.9)	<0.0001
Medicare	24.7 (12.1)	41.0 (9.1)	<0.0001
Dual-eligible	1.1 (0.8)	0.5 (0.4)	0.0034
Characteristics of inpatients			
Mean (SD) % of inpatients who are female	53.1 (6.4)	58.8 (5.0)	0.0023
Mean (SD) % inpatients with a race of:			
White	58.2 (24.8)	64.8 (16.7)	0.3263
Black/African American	15.3 (14.4)	11.6 (9.7)	0.3450
Asian/Pacific Islander	7.5 (4.3)	9.9 (4.8)	0.1180
Native American/Alaska Native	0.9 (0.01)	0.3 (0.4)	0.0083
Other	17.1 (15.5)	11.3 (10.6)	0.1714
Missing	1.0 (1.0)	2.1 (2.4)	0.1254
Mean (SD) % of inpatients who were Hispanic	38.2 (22.7)	26.8 (15.2)	0.0520
Mean (SD) % of inpatients with:			
Medicaid	33.8 (15.2)	14.8 (14.0)	0.0001
No insurance	14.8 (11.5)	4.0 (2.4)	<0.0001
Medicare	23.0 (11.3)	35.4 (9.3)	0.0003
Dual-eligible	2.6 (2.2)	1.1 (1.1)	0.0055

Notes: The matched hospitals are private hospitals that are matched on driving distance, ED volume, and bed size. Descriptive statistics used chi-square for categorical variables and *t* test and Wilcoxon-Mann-Whitney test for continuous variables. In the table above describing the race of hospital patients, we exclude seven hospitals from the ED rows and four hospitals from the inpatient rows that describe more than 50% of their patients' races as "other" or more than 5% of their patients' race are missing. "No insurance" includes patients whose expected payor is county indigent programs, other indigent, or self-pay.
Authors' analysis of data from ambulance diversions logs and emergency department and inpatient discharge data from the State of California Office of Statewide Health Planning and Development data, 2007.

TABLE 2 Linear probability model regression with hospital random effects for whether a hospital declares a diversion

	Coefficient	95% Confidence interval	*P*-value
Whether neighboring hospital is a public hospital	1.15	[0.84, 1.46]	<0.001
ED occupancy, log	0.21	[0.15, 0.26]	<0.001
ED occupancy, log x whether neighboring hospital is a public hospital	−0.25	[−0.31, −0.19]	<0.001
N	38 371		

Notes: A positive coefficient indicates that the variable is associated with an increased probability of declaring a diversion. Possible endogeneity for daily ED occupancy is addressed with instrumental variables, where the instrument is daily inpatient occupancy. Models control for teaching status, bed size, ratio of patients to emergency physicians with privileges, relative distance between hospital and neighboring hospital, overlap in patient catchment areas using the competitor market presence (Appendix S2), duration of the neighboring hospital's diversion, and whether the local EMS agency region experienced an unusually high ED volume, month, hour, whether the diversion is on a weekend. The model additionally controls for whether the neighboring hospital is a public hospital, interacted with ED occupancy, the hour, whether the diversion is on a weekend, and the ratio of patients to emergency physicians with privileges.
Authors' analysis of data from ambulance diversions logs and emergency department and inpatient discharge data from the State of California Office of Statewide Health Planning and Development data, 2007.

TABLE 3 Linear regression with hospital random effects for duration of diversion when a neighboring hospital is already on diversion

	Coefficient	95% Confidence interval	*P*-value
Whether neighboring hospital is a public hospital	−2.58	[−3.28, −1.89]	<0.001
ED occupancy, log	−5.22	[−8.30, −2.14]	0.001
N	11 641		

Notes: A negative coefficient indicates that the variable is associated with a shorter diversion. Controlling for teaching status, bed size, ratio of patients to emergency physicians with privileges, relative distance between hospital and neighboring hospital, overlap in patient catchment areas using the competitor market presence (Appendix S2), duration of the neighboring hospital's diversion, whether the local EMS agency region experienced an unusually high ED volume, month, hour, and whether the diversion is on a weekend. The sample consists of hospitals that declare a diversion following a diversion by a neighboring hospital, and excludes diversions that last longer than 171 min.
Authors' analysis of data from ambulance diversions logs and emergency department and inpatient discharge data from the State of California Office of Statewide Health Planning and Development data, 2007.

before the neighboring hospital ends its diversion; Appendix S6). In adjusted analyses, consistent with crowding being a cause of diversion, sequentially declaring a diversion in adjusted analyses is positively associated with a hospital's ED occupancy (log-transformed ED occupancy: 0.21, $P < 0.001$; Table 2). In unadjusted analyses, which does not consider ED occupancy, diversion-specific characteristics, hospital-pair-specific characteristics, or hospital characteristics, sample hospitals are more likely to declare a diversion if the neighboring hospital was private (34.4 percent, N = 5729) than public (30 percent, N = 6516; $P < 0.001$; Appendix S6). However, this relationship is opposite in adjusted analyses. This sign change between the unadjusted and the adjusted results occurs after adjusting for the number of patients in the ED interacted with whether the neighboring hospital on diversion is public vs private (ie neighbor ownership x ED crowding from Equation 1).

In adjusted analyses, sample hospitals are on average 1.2 percentage points ($P < 0.001$) more likely to declare a diversion if the neighboring diverting hospital is public rather than private, which corresponds to a 3.6 percent increase in the probability of diversion. Furthermore, sample hospitals that divert following the diversion of a neighboring public hospital are more likely to have fewer patients in the ED than those that divert following the diversion of a neighboring private hospital (log-transformed ED occupancy x whether the neighboring hospital is public, −0.25, $P < 0.001$). In other words, ED occupancy matters less when hospitals declare a diversion following the diversion of a neighboring public, vs private, hospital.

In our sample, hospitals are on diversions for a mean of 61.87 minutes (unadjusted; not shown). In adjusted analyses, when a neighboring hospital is already on diversion, hospitals' diversions are an average of 2.58 minutes shorter when the neighboring hospital is

TABLE 4 Linear regression with hospital random effects for time elapsed from when a neighboring hospital ended its diversion and hospital of interest ended its own diversion

	Coefficient	95% Confidence interval	*P*-value
Whether neighboring hospital is a public hospital	−1.28	[−2.38, −0.19]	0.022
ED occupancy, log	−1.85	[−6.64, 2.93]	0.448
N	11 163		

Notes: A negative coefficient indicates that the variable is associated with a shorter time that elapses between when the neighboring hospital ends its diversion and the observation hospital ends its own diversion. Controlling for teaching status, bed size, ratio of patients to emergency physicians with privileges, relative distance between hospital and neighboring hospital, overlap in patient catchment areas using the competitor market presence (Appendix S2), duration of the neighboring hospital's diversion, whether the local EMS agency region experienced an unusually high ED volume, month, hour, and whether the diversion is on a weekend. The sample consists of hospitals that declare a diversion following a diversion by a neighboring hospital where the neighboring hospital ends its diversion first, and excludes diversions where the time elapsed between the neighboring hospital ending its diversion and the hospital of interest ending its own diversion is greater than 119 min.
Authors' analysis of data from ambulance diversions logs and emergency department and inpatient discharge data from the State of California Office of Statewide Health Planning and Development data, 2007.

a public hospital, compared to a nonpublic hospital ($P < 0.001$), or an average decrease of 4.2 percent (Table 3).

Finally, when a hospital goes on diversion following a neighboring hospital's diversion and the neighboring hospital ends its diversion first, the second hospital ends its diversion a mean of 31.1 minutes after the neighboring hospital ends its own diversion (unadjusted; not shown). In adjusted analyses, hospitals end their diversions an average of 1.3 minutes sooner when the neighboring hospital is a public hospital, vs a private hospital 22 (ie, $P = 0.022$), corresponding to a 4.2 percent decrease in time of diversion (Table 4).

Alternative model specifications (ie without instrumental variables; using clustered standard errors; and including outliers) have similar results (Appendix S3). Using slightly different data, we find that the duration between the second and the third hospital to declare a diversion is shorter when the first hospital to declare a diversion is public vs private ($P = 0.040$; Appendix S4). There is no significant difference in severity of illness (Charlson index) in observation hospitals that divert after a neighboring public, vs private, hospital diverts (Appendix S5).

5 | DISCUSSION

This study examines whether hospitals respond differently to diversions by neighboring public, vs private, hospitals, comparing diversion probability and timing when neighboring public vs private hospitals of similar size and distance divert. These results provide evidence that hospitals in our sample are strategically declaring and ending diversions to avoid patients that would otherwise have been taken by ambulances to neighboring public hospitals. Given the substantial number of factors that can trigger a diversion, the magnitude of the estimated effects (3.6 percent increase in likelihood of diversion, 4.2 percent shorter duration, 4.2 percent reduction in time to reopening) is material and the fact that diversions occur at lower ED occupancy levels reinforces the evidence of strategic diversion. The probability of diversion is more significant to patients than the reduction in time to reopening; of the 6516 diversions in our sample that occurred when the neighboring diverting hospital was public, 263 diversions might not have occurred had the neighboring diverting hospital been a private hospital instead.[†]

There may be other explanations for these findings. One is that public hospitals are uniquely seen as "bellwethers" in some markets, such that hospitals are more likely to respond to their diversion activity as compared to diversions by other hospitals. However, it is difficult to understand why sample hospitals might selectively treat public hospitals this way, but not private hospitals that are matched by size and distance.

A second explanation is that hospitals in our sample declare diversions because they are being sent patients diverted from public hospitals, and these patients are of higher acuity. We think this unlikely because we do not see any significant differences in severity of illness in ED patients depending on whether neighboring hospitals are public vs private (Appendix S5). Furthermore, if patient acuity were affecting results, we would expect to see that sample hospitals' diversions would be longer when a neighboring hospital is public, vs private, so that the hospital would have time to treat the diverted patients with higher acuity. On the other hand, if hospitals were driven by strategic diversion, we hypothesized that hospitals would want to be on diversion for less time because they risk losing paying patients. Consistent with our hypothesis, our results show that sample hospitals' diversions are shorter when the neighboring hospital on diversion is public vs private. Thus, it seems unlikely that patient acuity drives our results.

A third explanation is that there is an unobserved cause for sample hospitals going on diversion when a neighboring public, vs private, hospital goes on diversion. We address this with a robust set of controls drawn from the literature, including notably those theorized in the Asplin et al's[29] input-throughput-output model, but as with any regression analysis, there may well be omitted variables

that explain the results. Our data do not permit us to measure the number of patients, degree of crowding, physician and nurse staffing patterns, and number of ED boarders at the moment a hospital declares a diversion. However, it is unlikely that these factors disproportionately dictate the observation hospital's decision to divert when the neighboring hospital that diverted was public vs private, particularly because patient acuity does not vary depending on whether the neighboring diverting hospital is public or private, as described above. In other words, although these variables may be important to understanding ED crowding, their omission likely does not bias our results. For instance, it is unlikely that the number of patients boarding at one hospital systematically changes depending on whether the neighboring diverting hospital is public vs private. This reasoning is supported by the literature. For instance, although ED boarding plays a large role in ED capacity, and is an important predictor of increased ambulance diversions,[2,30-32] studies of the predictors of ambulance boarding have focused on within-hospital differences as potential causes of boarding,[33-35] rather than the identity of neighboring hospitals that are diverting.

Our estimates of strategic diversions may be conservative, since we do not engage in further identification to select which hospitals may be more likely to game. In addition, all but two of the private hospitals in this study are nonprofit hospitals; for-profit hospitals may be more likely to strategically divert.

This study is subject to some limitations beyond those noted above. We used 2007 data because this year was the last that Los Angeles County, which accounts for 22 percent of all California hospitals, provided detailed diversion log data. Despite the age of the data, this study is still relevant given the continued importance of diversions in California. While some jurisdictions have moved to no-diversion policies since 2007, including Massachusetts, California has not. In fact, diversions continue to be extremely important in California—in 2015, almost half (45 percent) of California hospitals with ED visits declared ambulance diversions. While this is a significant decrease since 2007 (from 63 percent, $P < 0.001$), the large percentage of hospitals declaring diversions suggests that diversions remain an important issue to California hospitals. Furthermore, the mean number of diversion hours by hospitals that declare diversions has remained high and has not changed significantly since 2007 (2007: 688 vs 2015: 683 hours, $P = 0.96$).[*] Finally, diversions will likely continue to be an issue both in California and nationally, given research that suggests that ED use and crowding did not decrease after Medicaid expansion[36] and might have increased.[37]

Our findings are based on data from California and in metropolitan or urban areas, which may be different from other markets. Finally, our study design relies on matching nonsafety net hospitals by size and distance to safety net hospitals. This helps improve the comparability of diversions at a hospital of interest. However, this design also limits the size of our sample. More study needs to be done to see if hospitals of varying size and in different states engage in similar behavior. In addition, further study needs to be done to qualitatively assess what hospital and EMS agency policies (formal and informal) may be more likely to result in strategic diversions.

Building on prior research regarding defensive diverting, this study finds that hospitals in our sample are more likely to defensively divert when the neighboring hospital is a public hospital, suggesting these hospitals may use diversions as a way to avoid treating Medicaid and uninsured patients. Strategic diversions of this kind delay access to emergency care for particularly vulnerable populations—delays that may increase mortality.[5] Strategic diversions are particularly concerning given previous research suggesting that minority patients are especially affected by diversions.[8,23,38] Vulnerable populations may be even further disadvantaged if hospitals strategically divert to avoid them. Thus, strategic diversions undermine the goal of EMTALA to ensure access to emergency care for all patients, regardless of ability to pay. More research is needed to examine whether hospitals outside of this sample also engage in strategic diversions. Unfortunately, this type of data is generally unavailable. Consistent with the goals of the Foundations for Evidence-Based Policymaking Act of 2018,[39] federal policy makers may wish to buttress EMTALA by collecting data on diversions.

If further research suggests that strategic diversions broadly occur, what can be done? Federal policy makers may wish to audit reasons for diversions or amend the list of EMTALA violations to include strategic diversions. It is also possible for state and local policy makers to address strategic diversions. There are several examples of existing policies that might be adopted. Outright bans on ambulance diversions would decrease strategic diversions, but do not address the underlying reasons for capacity-based diversions, that is ED crowding. Although studies on a ban on ambulance diversions adopted by Massachusetts in 2009 did not find negative consequences,[40,41] these results may not be applicable to all jurisdictions if it were extended. A less sweeping approach would be to limit or promote standards governing the declaration of diversions. Hospitals vary a great deal in terms of when they declare diversions, who is responsible for declaring them (ie physicians, nursing staff, and hospital administrators), and the standards they use to make the determination.[11,42] Implementing a standardized procedure,[43,44] such as using measures such as the Emergency Department Work Index (EDWIN)[30] or the National Emergency Department Overcrowding Scale (NEDOC),[45] might help reduce strategic diversions, although standardizing procedures could be difficult to implement.[9,31,46]

Alternatively, local EMS agencies might help the standardization process by requiring more information from hospitals before they declare a diversion. EMS agencies in some jurisdictions already do this; for instance, Alameda County, California, requires that hospitals self-report patient census, bed availability, number of patients in the ED waiting room, and number of boarded patients.[47]

6 | CONCLUSION

Our data show that hospitals in our sample may respond differently to diversions of neighboring public, vs private, hospitals. Previous research suggests that minorities and low-income are particularly adversely affected by diversions, with higher mortality than

nonminorities and the higher-income.[8,23,38] This study suggests that not only might this population be adversely affected directly by diversions of public hospitals, but that they may also be more affected by sequential diversions, because private hospitals may be more likely to declare diversions after the neighboring public (vs private) hospital declares diversion. Furthermore, the results are consistent with our hypothesis that the difference in sequential diversion may be occurring because hospitals wish to avoid serving more uninsured and Medicaid patients. Given the potential impact of the observed differences on health outcomes, there may be opportunity for interventions at the local, state, and federal levels to improve the current structures influencing hospital diversion.

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ENDNOTES

* Authors' calculations from the Office of Statewide Health Planning and Development, "Emergency Department Services—Ambulance Diversion Trend," available at: https://data.chhs.ca.gov/dataset/emergency-department-services-ambulance-diversion-trend

† In our sample, there are 21 712 observations where the neighboring diverting hospital is a public hospital (not shown). When the neighboring diverting hospital is a public hospital, the hospital of interest declares a diversion 30% of the time (equivalent to 6516 diversions; Appendix Exhibit S6). The adjusted results suggest that 1.2 percentage points of this 30% may be attributed to the fact if the neighboring diverting hospital was a public, vs private, hospital. This corresponds to 263 diversions (6516-21 712 × (30-1.2)/100 = 263).

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REFERENCES

1. Burt CW, McCaig LF. Staffing, capacity, and ambulance diversion in emergency departments: United States, 2003-04. *Adv Data*. 2006;376:1-23.
2. Schull MJ, Lazier K, Vermeulen M, Mawhinney S, Morrison LJ. Emergency department contributors to ambulance diversion: a quantitative analysis. *Ann Emerg Med*. 2003;41(4):467-476.
3. Schull MJ, Morrison LJ, Vermeulen M, Redelmeier DA. Emergency department gridlock and out-of-hospital delays for cardiac patients. *Acad Emerg Med*. 2003;10(7):709-716.
4. Sun BC, Hsia RY, Weiss RE, et al. Effect of emergency department crowding on outcomes of admitted patients. *Ann Emerg Med*. 2013;61(6):605-611.
5. Shen YC, Hsia RY. Ambulance diversion associated with reduced access to cardiac technology and increased one-year mortality. *Health Aff (Millwood)*. 2015;34(8):1273-1280.
6. Yankovic N, Glied S, Green LV, Grams M. The impact of ambulance diversion on heart attack deaths. *Inquiry*. 2010;47(1):81-91.
7. Shen YC, Hsia RY. Association between ambulance diversion and survival among patients with acute myocardial infarction. *JAMA*. 2011;305(23):2440-2447.
8. Hsia RY, Sarkar N, Shen YC. Impact of ambulance diversion: black patients with acute myocardial infarction had higher mortality than whites. *Health Aff*. 2017;36(6):1070-1077.
9. McCarthy ML, Aronsky D, Jones ID, et al. The emergency department occupancy rate: a simple measure of emergency department crowding? *Ann Emerg Med*. 2008;51(1):15-24, 24 e11-e12.
10. United States General Accounting Office. *Hospital Emergency Departments: Crowded Conditions Vary Among Hospitals and Communities*. Washington, DC: United States General Accounting Office; 2003.
11. Mihal N, Moilanen R. *When Emergency Rooms Close: Ambulance Diversion in the West San Fernando Valley*. Los Angeles, CA: Ralph and Goldy Lewis Center for Regional Policy Studies, UCLA School of Public Affairs, UC Los Angeles; 2005.
12. Hagtvedt R, Ferguson M, Griffin P, Jones GT, Keskinocak P. Cooperative strategies to reduce ambulance diversion. In: Rossetti MD, Hill RR, Johansson B, Dunkin A, Ingalls RG, eds. *Proceedings of the 2009 Winter Simulation Conference*. Austin, TX: Curran Associates; 2009.
13. Deo S, Gurvich I. Centralized vs. decentralized ambulance diversion: a network perspective. *Manage Sci*. 2011;57(7):1300-1319.
14. Falvo T, Grove L, Stachura R, Zirkin W. The financial impact of ambulance diversions and patient elopements. *Acad Emerg Med*. 2007;14(1):58-62.
15. McConnell KJ, Richards CF, Daya M, Weathers CC, Lowe RA. Ambulance diversion and lost hospital revenues. *Ann Emerg Med*. 2006;48(6):702-710.
16. Wilson M, Cutler D. Emergency department profits are likely to continue as the affordable care act expands coverage. *Health Aff*. 2014;33(5):792-799.
17. Hsia RY, MacIsaac D, Baker LC. Decreasing reimbursements for outpatient emergency department visits across payer groups from 1996 to 2004. *Ann Emerg Med*. 2008;51(3):265-274, 274.e261-e265.
18. Scott JW, Havens JM, Wolf LL, et al. Insurance status is associated with complex presentation among emergency general surgery patients. *Surgery*. 2017;161(2):320-328.
19. Studdert DM, Thomas EJ, Burstin HR, Zbar BI, Orav EJ, Brennan TA. Negligent care and malpractice claiming behavior in Utah and Colorado. *Med Care*. 2000;38(3):250-260.
20. Deane L. The cost of lawsuit risks when treating the uninsured. *Health Aff*. 2010;29(11):2127; author reply 2128.
21. Burditt v. US Dept. of Health and Human Services, 934 F.2d 1362 (5th Cir. 1991).

22. The Emergency Medical Treatment and Labor Act, 42 USC §1395dd et seq.
23. Hsia RY, Asch SM, Weiss RE, et al. California hospitals serving large minority populations were more likely than others to employ ambulance diversion. *Health Aff*. 2012;31(8):1767-1776.
24. Abaris Group. *California ED Diversion Project, Final Report*. Walnut Creek 2009.
25. Wooldridge JM. *Econometric Analysis of Cross Section and Panel Data*, 2nd edn. Cambridge, MA: MIT Press; 2002.
26. Burt CW, McCaig LF, Valverde RH. Analysis of ambulance transports and diversions among US emergency departments. *Ann Emerg Med*. 2006;47(4):317-326.
27. Sun BC, Mohanty SA, Weiss R, et al. Effects of hospital closures and hospital characteristics on emergency department ambulance diversion, Los Angeles County, 1998 to 2004. *Ann Emerg Med*. 2006;47(4):309-316.
28. Brooks GR, Jones VG. Hospital mergers and market overlap. *Health Serv Res*. 1997;31(6):701-722.
29. Asplin BR, Magid DJ, Rhodes KV, Solberg LI, Lurie N, Camargo CA Jr. A conceptual model of emergency department crowding. *Ann Emerg Med*. 2003;42(2):173-180.
30. Bernstein SL, Verghese V, Leung W, Lunney AT, Perez I. Development and validation of a new index to measure emergency department crowding. *Acad Emerg Med*. 2003;10(9):938-942.
31. Epstein SK, Tian L. Development of an emergency department work score to predict ambulance diversion. *Acad Emerg Med*. 2006;13(4):421-426.
32. Institute of Medicine. *Hospital-Based Emergency Care: At the Breaking Point*. Washington, DC: Institute of Medicine; 2007.
33. Rabin E, Kocher K, McClelland M, et al. Solutions to emergency department 'boarding' and crowding are underused and may need to be legislated. *Health Aff*. 2012;31(8):1757-1766.
34. Zhou JC, Pan KH, Zhou DY, et al. High hospital occupancy is associated with increased risk for patients boarding in the emergency department. *Am J Med*. 2012;125(4):416.e411-416.e417.
35. Shaikh SA, Robinson RD, Cheeti R, et al. Risks predicting prolonged hospital discharge boarding in a regional acute care hospital. *BMC Health Serv Res*. 2018;18(1):59.
36. Pines JM, Zocchi M, Moghtaderi A, et al. Medicaid expansion in 2014 did not increase emergency department use but did change insurance payer mix. *Health Aff*. 2016;35(8):1480-1486.
37. Nikpay S, Freedman S, Levy H, Buchmueller T. Effect of the affordable care act medicaid expansion on emergency department visits: evidence from state-level emergency department databases. *Ann Emerg Med*. 2017;70(2):215-225. e216.
38. Shen YC, Hsia RY. Do patients hospitalised in high-minority hospitals experience more diversion and poorer outcomes? A retrospective multivariate analysis of Medicare patients in California. *BMJ Open*. 2016;6(3):e010263.
39. Foundations for Evidence-Based Policymaking Act of 2018, Pub. L. No 115-435, 132 Stat. 5529 (2019).
40. Burke LG, Joyce N, Baker WE, et al. The effect of an ambulance diversion ban on emergency department length of stay and ambulance turnaround time. *Ann Emerg Med*. 2013;61(3):303-311.
41. Rathlev NK, Blank F, Osborne B, et al. No diversion in Western Massachusetts. *J Emerg Med*. 2013;44(2):313-320.
42. Handel DA, Pines J, Aronsky D, et al. Variations in crowding and ambulance diversion in nine emergency departments. *Acad Emerg Med*. 2011;18(9):941-946.
43. Hoot N, Aronsky D. An early warning system for overcrowding in the emergency department. *AMIA… Annual Symposium proceedings. AMIA Symposium*. 2006:339-343.
44. Weiss SJ, Ernst AA, Nick TG. Comparison of the National Emergency Department Overcrowding Scale and the Emergency Department Work Index for quantifying emergency department crowding. *Acad Emerg Med*. 2006;13(5):513-518.
45. Weiss SJ, Derlet R, Arndahl J, et al. Estimating the degree of emergency department overcrowding in academic medical centers: results of the National ED Overcrowding Study (NEDOCS). *Acad Emerg Med*. 2004;11(1):38-50.
46. Hoot NR, Zhou C, Jones I, Aronsky D. Measuring and forecasting emergency department crowding in real time. *Ann Emerg Med*. 2007;49(6):747-755.
47. Alameda County Emergency Medical Services. *Ambulance Diversion*. Oakland, CA; 2009.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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